Effect of Rescattering on Initial Anisotropic High Density Domain

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One of the important physics results learned from heavy ion collisions at AGS and SPS energies is that there is a large amount of particle rescattering in central collisions. The RQMD transport model shows that particle rescattering reduces pion multiplicity by 8% at SPS energy.[1] An interesting consequence of this is that a non-spherical, high energy density domain, which can be formed at early stage of a heavy ion collision due to fluctuations in energy deposition, may produce an anisotropy in pion emission at freeze-out. It is the goal of the present work to study the possible magnitude of such an anisotropy.

We used RQMD version 2.3 to simulate head-on Pb+Pb collisions at SPS energy (158 GeV/nucleon). The model is modified in the following way to create a non-spherical, high energy density domain: at $t = 1$ fm in the center of mass frame, a fraction of particles/strings with rapidity $|y| < 1.5$ are randomly chosen and moved into an elliptical cylinder of size 8 fm $\times$ 2 fm by changing their transverse x, y positions only. Fig. 1 shows the resulting particle density projected on the $z = 0$ plane. The total energy and momentum are conserved by this procedure, but the collision dynamics are modified. After the re-arrangement, RQMD is properly re-initialized and run until freeze-out.

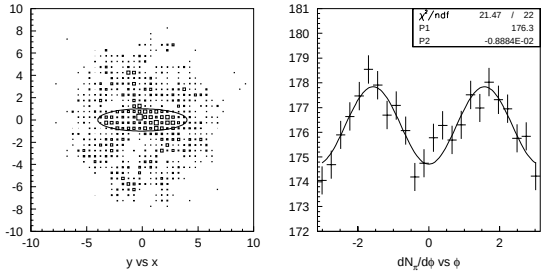

Figure 1: [left] Particle density projected on the $z = 0$ plane. The high density domain is shown in the sketched ellipse. [right] Azimuthal distribution of charged pion multiplicity with $|y| < 2$. $\phi = 0$ is along the major axis of the ellipse.

We have studied two cases: 20% (10%) of the particles/strings are modified, resulting in a 80% (40%) increase of total energy within the cylinder and a 40–50% (20–30%) increase in the total number of binary collisions.

Although the energy density in the central elliptical cylinder is artificially increased at the initial stage, the freeze-out density is similar to that in a normal RQMD event. However, the freeze-out pion distribution is azimuthally asymmetric, and can be described by the functional form $1 - \alpha \cos(2\phi)$. As shown in Fig. 1, there are fewer pions emitted along the major axis of the ellipse, in agreement with the picture that pion yield is reduced by rescattering. (It should be noted that this result qualitatively agrees with the result that the elliptic flow is in-plane at SPS energy at medium impact parameter[2] where the initial geometry is similar to the high density domain studied here.) The magnitude of the asymmetry depends upon pion transverse momentum, $p_\perp$ (GeV/c); the higher $p_\perp$, the greater anisotropy. The results for various $p_\perp$ cuts are summarized in Table 1. There is no difference observed between π^+ and π^-. Note that only fractions of particles/strings within $|y| < 1.5$ are modified; the anisotropy appears only for particles within $|y| < 2$.

Case	$p_\perp < 0.5$	$p_\perp > 0.5$	$p_\perp > 0.8$	All $p_\perp$
20%	0.5%	1.5%	2%	0.9%
10%	$\simeq 0$	0.9%	1.4%	0.35%

Table 1: Pion emission anisotropy, α, resulting from initial anisotropic high density domain

The current study is done on an inclusive basis. Since energy fluctuation is an event-by-event phenomenon, the physics has to be studied event-by-event, which will be challenging given the amplitude of the effect shown by the present work.

Footnotes and References

[1] H. Sorge, *Phys. Rev.* **C52**, 3291–3314 (1995).

Footnotes and References

[2] *Phys. Rev. Lett.*, submitted (1998).